ELECTRICAL LABORATORY

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EVALUATING TRANSFORMER NOISE REQUIREMENTS

November 30, 1993

1 January 24, 1994

This procedure for determining an acceptable level of transformer noise uses as the final criterion the A-weighted sound level which is consistent with the National Electrical Manufacturer's Association (NEMA) standards for transformers. Transformer manufacturers have been reluctant to guarantee transformer noise levels based on octave band data or tonal characteristics, and to do so might increase costs considerably. Although this evaluation's final criterion is a single A-weighted value, the procedure employs octave band data and considers significant transformer frequencies as contained within their respective octave bands.

Octave band data is reasonably easy to acquire and much informative noise data is based on octave bands. Also, some definitive noise regulations require the use of octave band data along with A-weighted values.

The procedure for determining transformer noise requirements is outlined on the worksheet on Page 9. A description of the steps, as shown on the worksheet follows.

Step 1. Average Minimum Ambient Noise

The average minimum ambient noise is a measure of the existing noise levels during quiet periods at critical locations, i.e., near residences or areas of leisure activity. Although the evaluation procedure utilizes only three octave bands, a complete octave band spectrum and A-weighted readings should be made for further reference or in the event of a request for such data by regulatory agencies. Measurements should be made from early summer to early fall, since this is the period when complaints usually occur because of longer hours of outdoor leisure activity and open bedroom windows. Measurements during two nighttimes, each on a different day of the week, are recommended unless experience indicates that a single night's measurement adequately describes the minimum ambient conditions. Generally, the quietest period is between midnight and 4:00 AM.

The major ambient noise is usually traffic. It is important to know if the traffic flow changes from day-to-day or weekdays-to-weekends so that the ambient noise measurements reflect the quieter periods. If measurements are not possible during the preferred season then seasonal changes in traffic should be determined and consideration given to establish the correct ambient noise level. Occasionally factory noise can influence the ambient noise. Since a transformer operates continuously it is important to know if the factory shuts down on weekends or other periods so that ambient noise measurements are made without the influence of temporary sources.

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The measured ambient noise.can be compared to noise data taken at locations with a similar area description to ascertain correctness. Comparisons can also be made with the noise data listed in Tables 1 and 2. In any event, a judgement must be made to determine if the ambient data are a reasonable measure of the minimum ambient conditions.

TABLE 1

Estimate of Outdoor Background Noise Based on General Type of Community Area and Nearby Automotive Traffic Activity.

Determine the conditions that best describe the area in question. Refer to the corresponding Noise Code Number in Table 2 for the average background noise levels. Nighttime noise levels should always be used. Daytime levels are provided for informative purposes.

CONDITION	NOISE CODE NUMBER
Nighttime, rural; no nearby traffic of concern	1
Daytime, rural; no nearby traffic of concern	2
Nighttime, suburban; no nearby traffic of concern	2
Daytime, suburban; no nearby traffic of concern	3
Nighttime, urban; no nearby traffic of concern	3
Daytime, urban; no nearby traffic of concern	4
Nighttime, business or commercial area	4
Daytime, business or commercial area	5
Nighttime, industrial or manufacturing area	5
Daytime, industrial or manufacturing area	6
Within 300 ft. of intermittent light traffic	4
Within 300 ft. of continuous light traffic	5
Within 300 ft. of continuous medium-density traffic	6

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CONDITION	NOISE CODE NUMBER
Within 300 ft. of continuous heavy-density traffic	7
300 to 1000 ft. from intermittent light traffic	3
300 to 1000 ft. from continuous light traffic	4
300 to 1000 ft. from continuous medium-density traffic	5
300 to 1000 ft. from continuous heavy-density traffic	6
1000 to 2000 ft. from intermittent light traffic	2
1000 to 2000 ft. from continuous light traffic	3
1000 to 2000 ft. from continuous medium-density traffic	4
1000 to 2000 ft. from continuous heavy-density traffic	5
2000 to 4000 ft. from intermittent light traffic	1
2000 to 4000 ft. from continuous light traffic	2
2000 to 4000 ft. from continuous medium-density traffic	3
2000 to 4000 ft. from continuous heavy-density traffic	4

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TABLE 2

Unweighted Octave Band Sound Pressure Levels in Decibels Re 0.0002 Microbar

Noise Code No. In Table 1	Octave Band Center Frequency - Hertz							
	63	125	250	500	1000	2000	4000	8000
1	40	37	32	27	22	18	14	12
2	45	42	37	32	27	23	19	17
3	50	47	42	37	32	28	24	22
4	55	52	47	42	37	33	29	27
5	60	57	52	47	42	38	34	32
6	65	62	57	52	47	43	39	37
7	70	67	62	57	52	48	44	42

Step 2. Transformer Noise Relative to the Ambient Noise

Determine the number of decibels that the transformer tones may exceed the ambient noise level in their respective octave bands. The following guidelines are given.

TRANSFORMER NOISE	COMMUNITY RESPONSE
Below the ambient	no complaints
0 to 5 dB above the ambient	little likelihood of complaints
6 to 10 dB above the ambient	some individual complaints
10 dB or more above the ambient	serious complaints

A transformer noise level up to 5 decibels above the ambient should be acceptable in most locations.

A transformer noise level not exceeding the ambient noise should be used in locations judged critical with respect to intruding noise. Possible critical locations include areas where the proposed substation is in a residential neighborhood where outside areas of homes are used for considerable leisure activity and where other potentially sensitive sound receptors may be present.

Step 3. Transformer Noise Criterion

The noise criterion is the summation of Steps 1 and 2.

Step 4. Transformer Noise Attenuation

As the noise from a transformer travels from its source to areas of concern, the noise is attenuated according to the laws of hemispherical spreading i.e., there is a reduction of approximately 6 decibels each time the distance doubles. Studies indicate there is no predictable directivity pattern, consequently the transformer should be treated as an omnidirectional source. Considering the transformer frequencies of interest along with distances commonly encountered between a transformer and residences, excess attenuation due to meteorological conditions can be ignored. Although dense growth hiding a substation can be psychologically advantageous, it offers little attenuation for the

lower transformer frequencies. Therefore, the distance correction can be determined by the following formulae.

If the transformer dimensions are known:

Attenuation in dB = 4.4 + 20 log (D/WH)

whereD = distance from the transformer
W = projected width of the transformer viewed by the listener at D
H = transformer height.

The above formula assumes that the sound transmission path is over a flat area free of obstruction and D is greater than 2WH or in the far field of the transformer.

If the transformer dimensions are not known:

Attenuation in dB = 20 log D - 1.9 log (KVA x KV) - 5.9

whereD = distance from the transformer
KVA & KV = rating of the transformer

Step 5. Transformer Noise at Source

The summation of Steps 3 and 4 gives the acceptable transformer noise in octave bands at the source.

Step 6. Conversion to A-weighting

These are the values to be subtracted from the transformer octave band levels to yield A-weighted values. The values were derived from actual measurements of numerous transformers.

Step 7. A-weighted Transformer Noise

A-weighted values are the result of subtracting Step 6 corrections from Step 5 values and represent A-weighted values as related to the three important octave bands.

Step 8. Transformer Noise Recommendation

The final A-weighted transformer noise level is the lowest value as determined in Step 7. The noise level recommended is the total noise from all transformers proposed for the substation.

Throughout this procedure the NEMA value referred to is the core noise, i.e., the noise level for the OA rating without forced cooling. With auxiliary cooling, the standard NEMA noise level is 2 to 3 dB higher. Although core noise is considered most important from an annoyance viewpoint, the wide band fan noise cannot be ignored. Thus any noise reduction determined in this procedure should be applicable to all classes of cooling.

In the event that the final A-weighted transformer noise value for a preferred installation is no more than 2 or 3 decibels above NEMA values, standard transformers might still be acceptable. Transformer noise studies have shown that standard transformers were quieter than the NEMA maximum value by an average of 4 dB. Dependence on this trend is not guaranteed. Before using any exceedence above recommended levels, the substation location and land use should be carefully considered.

Step 9. NEMA Standard Noise Level

This is the noise level of a standard transformer for the OA rating, as determined from Table 0-1, of NEMA Standards Publication No. TR-1. If more than one transformer is considered, the noise contribution of all transformers should be combined on an energy basis and the total NEMA noise level used.

Step 10. Noise Reduction Required

If the NEMA standard noise level in Step 9 is lower than the recommended transformer noise level in Step 8, standard transformers are acceptable. If the NEMA standard noise level is greater than the value for an acceptable installation, the difference is then the noise reduction required for each transformer.

Transformers are usually purchased with a noise reduction of 10 dB below standard levels. The cost adder for this approach is approximately 5%.

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WORKSHEET I

Procedure for Evaluating Transformer Noise Requirements

SUBSTATION _____

STEP	*SpL in dB re 0.0002 Microbar Octave Band Center Frequency - Hz		
	125	250	500
1. +Average minimum ambient noise			
2. +Allow transformer noise ___ dB above ambient			
3. Noise criterion (Step 1 plus 2)			
4. +Distance correction for ___ feet			
5. Allowable transformer noise at source (Step 3 plus 4)			
6. Convert to A-weighting	-13	-6	-1
7. A-weighted transformer noise (Step 5 minus 6)			

8. Final A-weighted value (Lowest of Step 7)	
9. +NEMA value for a standard unit	
10. Amount of noise reduction needed (Step 9 minus 8)	

+

1. By measurement
2. Response criterion
4. Calculation based on transformer dimensions or rating
9. From Standard TR-1

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* - Unweighted